Return to Equipment Evaluations

52-22 Accuracy of Commercial Radiometers (Project 96-71) (9/97)

OBJECTIVE: Early curing lights were provided with a single curing tip which was usually 7- to 8-mm in diameter. Because light units are being used for a broader range of clinical applications, manufacturers have developed additional tip sizes and shapes. The commercially-available hand-held radiometers have a fixed-diameter aperture and a detector that calculates irradiance based on the area of the fixed-aperture. The irradiance values measured by these fixed-aperture radiometers may be inaccurate when larger- or smaller-diameter curing tips are used, because irradiance is a measure of power divided by the area of the light source. The purpose of this evaluation was to determine the accuracy of four commercially-available radiometers when curing tips of different diameters were used.

Table 1. Radiometers Evaluated

MODEL	MANUFACTURER	DISPLAY	POWER	RETAIL COST	GOVERNMENT COST
Demetron Model 100	Demetron Research Danbury, CT (800) 444-3587	Analog	Light From Curing Tip	$175.00	$81.95
CaulkCure-Rite	L.D. Caulk Milford, DE (800) 532-2855	Digital	9-volt Battery	$223.35	$118.82
CotoluxPower Meter	Coltene/Whaledent Mahwah, NJ (800) 221-3046	Digital	9-volt Battery	398.35	$81.87
Optilux Built-in	Demetron Research Danbury, CT (800) 444-3587	Digital	Optilux 500 Curing Light	Included in price of Optilux 500	Included in price of Optilux 500

METHODS AND MATERIALS:

Three commercial hand-held radiometers (Demetron model No. 100, Caulk Cure-Rite, Cotolux Power Meter) and a built-in visible light curing unit radiometer (Demetron Optilux 500) were used in this study. The irradiance values measured by the commercially-available radiometers were compared to the values determined by a laboratory-grade power meter (Molectron PowerMax 500D with PM10 Probe, Molectron Detector, Inc., Portland, OR). A Demetron Optilux 500 visible-light-curing unit with a new 80-watt quartz-halogen Demetron OptiBulb was used as the light source for all measurements. The means and standard deviations were calculated for each individual radiometer. For each diameter tip, a Student's t-test at the 0.05 level of significance was used to compare the irradiance measured by each model of radiometer to the irradiance measured by the PowerMax 500D. A one-way analysis of variance at the 0.05 level of significance was used to compare the irradiance values among the five samples of each commercially-available radiometer model and to compare the irradiance values measured by each radiometer brand.

RESULTS:

The data are reported in Tables 2 & 3 and depicted graphically in Figures 1- 4. Table 2 presents the mean irradiance values measured by each brand of radiometer and the PowerMax 500D. Table 3 reports the percentage error for each brand of radiometer either above or below the correct irradiance as measured by the PowerMax 500D. Except for the Demetron built-in radiometer with the 10.5-mm tip, all the commercially-available radiometers exhibited irradiance values statistically different from those of the PowerMax 500D. There were no statistically significant differences among the five samples of each commercially-available radiometer model, but there were significant differences when different manufacturer's models were compared.

Table 2. Measured Irradiance (mW/cm2)

	4-mm tip	7.5-mm tip	10.5-mm tip	12-mm tip
PowerMax 500D	2574 ± 49	893 ± 6	749 ± 12 **	547 ± 7
Demetron Built-In	684 ± 34	738 ± 28	752 ± 12 **	618 ±27
Demetron Model 100	713 ± 33	812 ± 25	834 ± 35	690 ± 20
Cure-Rite	890 ± 16	876 ± 22	861 ± 35	715 ± 23
Cotolux	789 ± 18	1030 ± 8	1237 ± 21	1086 ± 23

Mean ± one standard deviation
** Not significantly different at $p < 0.05$
n=5

Table 3. Percentage Error Compared to Laboratory-Grade Power Meter

	4-mm tip	7.5-mm tip	10.5-mm tip	12-mm tip
Demetron Built-In	276% -	21% -	0%	11% +
Demetron Model 100	261% -	10% -	10% +	21% +
Cure-Rite	186% -	2% -	13% +	23% +
Cotolux	226% -	13% +	39% +	50% +

n=5
+=Percentage radiometer measured above actual irradiance
-=Percentage radiometer measured below actual irradiance

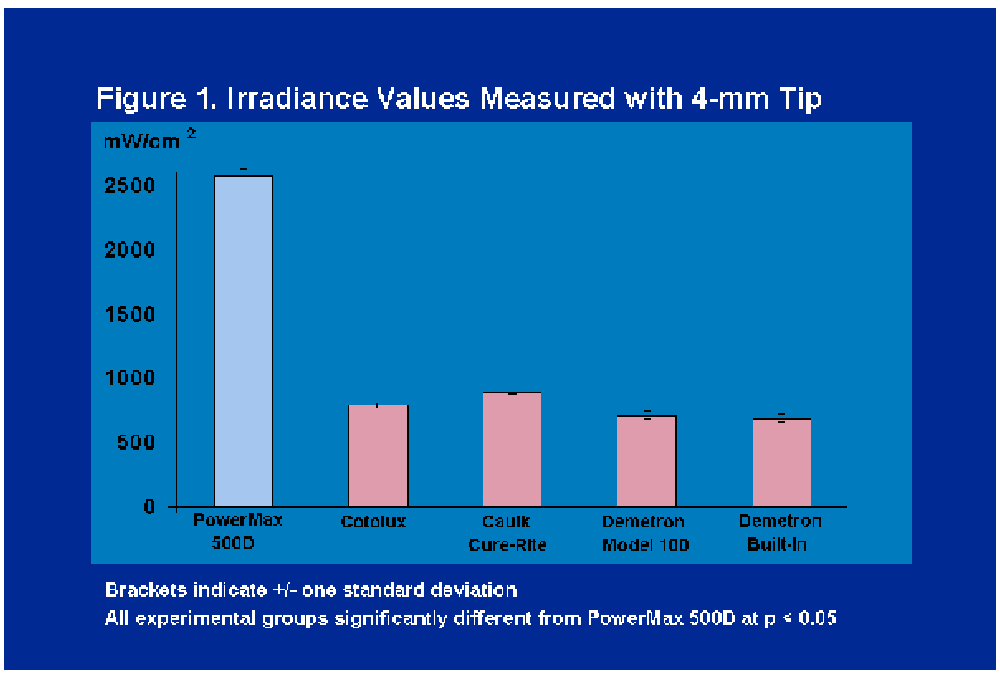
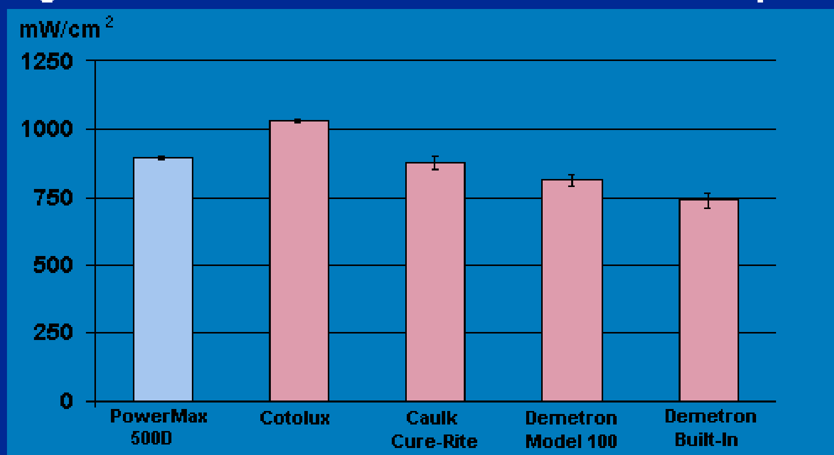
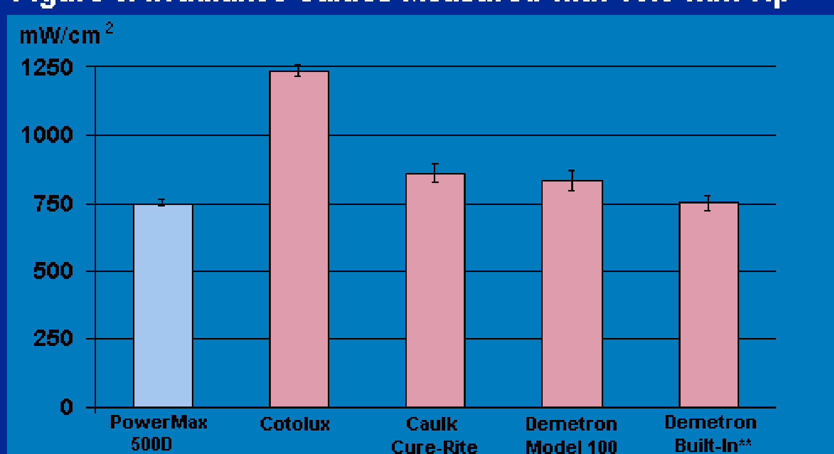


Figure 2. Irradiance Values Measured with 7.5-mm Tip



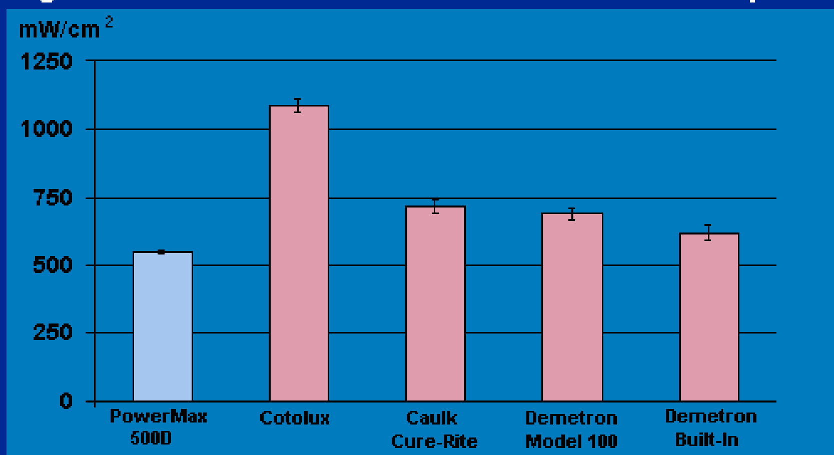
Brackets indicate +/- one standard deviation
All experimental groups significantly different from PowerMax 500D at $p < 0.05$

Figure 3. Irradiance Values Measured with 10.5-mm Tip



Brackets indicate +/- one standard deviation
**Not statistically different from PowerMax 500D at $p < 0.05$

Figure 4. Irradiance Values Measured with 12-mm Tip



Brackets indicate +/- one standard deviation
All experimental groups significantly different from PowerMax 500D at $p < 0.05$

SUMMARY AND CONCLUSIONS:

The effect of different-diameter curing tips on the accuracy of four commercially-available radiometers was evaluated by comparing them to the laboratory-grade power meter. The results indicate that the commercially-available radiometers used in this evaluation are poor indicators of the actual irradiance generated by visible-light-polymerization units. The degree of inaccuracy of their values also varied based on the diameter of the tip being measured. The commercial radiometers generally gave irradiance values that were from 11 to 50 percent higher than actually existed for the 12-mm diameter tip. If this inaccuracy holds true throughout the irradiance range of the visible-light curing unit, the impact of this on clinical procedures could be substantial. If light units are being measured that have irradiance values close to the minimally acceptable value (i.e., »300 mW/cm^2), the actual light output would be inadequate for curing purposes.

The commercial radiometers gave irradiance values that were from 186 to 276 percent lower than actually existed for the 4-mm diameter tips and tended to be more accurate when measuring irradiance with 7.5-mm and 10.5-mm tips. The irradiance values of different brands of radiometers varied, however values from model to model within the brands, while inaccurate, were consistent.

Commercial radiometers, despite their limitations, are still a valuable tool for the practitioner to monitor curing lights. If used correctly, they provide a quick and relatively inexpensive means of assessing curing light performance. Initial baseline irradiance with a new bulb should be compared to subsequent irradiance values over time using the same diameter tip. Their use should be limited to this function only and the irradiance values obtained should not be considered absolute.